Idaho National Engineering & Environmental Laboratory
Bechtel BWXT Idaho LLC.

# CATALYTIC OXIDIZER UNIT

Summary:
The Catalytic Oxidizer has been installed as part of the vapor vacuum extraction system in the Subsurface Disposal Area of the Radioactive Waste Management Complex. It is a critical part of the Organic Contamination of the Vadose Zone (OCVZ) project. A vacuum blower draws volatile organic compound (VOC) vapor from subsurface extraction wells into a heated reactor where spontaneous reaction with air in the presence of a reactive solid surface occurs. The OCVZ Project utilizes this technology to oxidize the volatile gases that are extracted from the contaminated vadose zone. This unit was manufactured for the INEEL by King, Buck Technology.

The King Buck Catalytic Oxidizer is a permanently mounted continuously operated gas/vapor thermal combustion system. The gas is pumped to the thermal treatment system where it is heated to its combustion temperature, oxidized and then released as a non-hazardous vapor to the atmosphere.
The King Buck unit is a fixed bed catalytic system. The incoming gases flow into a heat exchanger, the gases pass through an electric heater to elevate the temperature to the requirements of the oxidizer, the gases then flow downward through a fixed-bed catalyst reactor (similar to what is used in U.S. automobiles), the gases exit the catalyst reactor and re-enter the heat exchanger (designed to recover waste heat from the treated gas reducing exhaust gas temperature and increasing thermal efficiency) and exit the unit through the exhaust stack. Operating temperature for the King Buck unit is 900F.

Vapor flow entering the catalytic oxidizer is directed through a vapor liquid separator to remove any free-phase liquids that may be entrained in the vapor flow at a maximum of 500 SCFM. If the vapor flow is excessively dry, additional deionized water may be added through a sparger to ensure complete saturation. The flow is then directed into the shell side of a shell and tube heat exchanger where heat is recovered from exhaust gases into the inlet flow. Exiting the heat exchanger, the inlet flow is conducted past an electric bayonet style heater where the temperature is elevated to the set point temperature of the catalytic process, nominally 900°F. Oxidation of chlorinated hydrocarbons occurs spontaneously over the catalytic surface using water as the hydrogen source for the reaction. Oxidation products are exhausted from the system through a 30-ft stack at approximately 500°F. The destruction / removal efficiency (DRE) for the catalytic oxidation system is 99.99%. While composed primarily of excess air, water, and oxidation products, trace quantities of unreacted volatile organic contaminants ($CCl_4$, C2HCl3, C2Cl4, C2H3Cl3) are expelled from the stack with the product gasses. The primary oxidation products are HCl and $CO_2$, with a lesser quantity of $Cl_2$. The presence of water in the inlet steam minimizes the production of $Cl_2$ relative to HCl.

The Unit D oxidizer is situated entirely within the modified steel enclosure at the Unit C site. This has the dual effect of minimizing the exposure of system components to the extreme environment at the RWMC (maximizing component lifetime), and minimizes the visual impact of the system.

A need existed to replace an older and malfunctioning thermal oxidizer unit. The technology also satisfies a need to improve ease of operation. The operation of this unit will reduce the time spent on troubleshooting and repairs, and less downtime will speed the destruction of VOCs.

| Qualitative Benefit Analysis | | |
|---|---|---|
| Programmatic Risk | ● | The new unit has the potential for reducing the programmatic risk associated with OCVZ because of its increased reliability and by improving the system's overall performance. With the shut down of one of the original units (Unit C) the volume of VOCs being treated had been reduced by approximately 33%. The new unit will avoid a reduction in the volume of treated VOCs. The new unit is capable of being connected to 4 extraction wells and has an increased flow rate of 500 SCFM up from 200 SCFM of the old units. This will permit the project to meet the objectives set forth in the OU 7-08 Record of Decision (ROD). |
| Technical Adequacy | ● | The design of the new King Buck unit is much more efficient than the existing Thermatrix units. A design flaw was discovered in the old design following unit failure.<br><br>The new unit, Unit D, holds several advantages over its predecessor including fully automated process control, simplified operation, streamlined design, increased flexibility of operation, simplified operating procedure, and reduced size.<br>The thermal unit required a great deal of intervention by the operator to actuate switches and valves to advance the system through the various phases of operation.<br><br>Operating temperatures are lower and costs to operate are less. |
| Safety | ◒ | The Unit D oxidizer does not require propane to operate. As such weekly delivery of propane to the Unit D site is no longer necessary. With this, the inherent risks associated with transport, delivery, storage, and use of a compressed flammable gas have been eliminated. The volume of inventoried chemical (propane) stored on site has also been reduced.<br><br>This unit operates at a temperature of 900 degrees F. instead of the 1600 – 1800 degrees of the older units. This lower temperature is inherently safer.<br><br>The destruction / removal efficiency (DRE) for the catalytic oxidation system is 99.99% which is greater than the 98.3% DRE measured for the old units. |

| | | |
|---|---|---|
| Schedule Impact | ◒ | Bringing this unit on-line will increase the quantity of VOCs eliminated and thus shorten the operational life of the OCVZ project. The ability to process and eliminate a greater volume of VOCs will reduce the quantity of contaminant in the vadose zone at a faster rate.<br><br>The operation of this unit will reduce the time spent on troubleshooting and repairs. Less downtime will speed the destruction of VOCs. |

| ● | ◒ | ○ | ◓ | ◉ |
|---|---|---|---|---|
| Major Improvement | Some Improvement | No Change | Somewhat Worse | Major Decline |

| Quantitative Benefit Analysis | |
|---|---|
| Cost Impact Analysis | Annual cost savings are derived from reductions in fuel, labor, maintenance and purchase costs. Several design factors for the unit contribute to cost savings. Because the air and propane subsystems are eliminated in the Unit D design, fewer major components (valves, transmitters, and sensors) are present. As a result less maintenance on the system is required.<br>In addition to these cost savings there is an expected increase in up-time of at least 20%.<br><br>Annual propane costs of about $72,800 will be reduced to about $29,000 in electricity for a savings of around $43,800. Labor support in planning, engineering and technicians will be reduced by about $81,000 annually. Maintenance reductions will save about $24,000 per year, and $25,000 will be saved on parts and materials. The purchase cost of the new equipment is approximately $250,000 less than the old units. The sum of these savings is over $400,000 per year and would be over $6,000,000 over a 15 year life span.<br>Annual Savings $436,363<br>Life Cycle Cost Savings $5,995,445<br>Return-On-Investment (ROI) 73% |

## Worksheet 1: Operating & Maintenance Annual Recurring Costs

| Expense Cost Items * | Before (B) Annual Costs | After (A) Annual Costs |
|---|---|---|
| 1. Equipment | $ 800,000.00 | $ 550,000.00 |
| 2. Purchased Raw Materials and Supplies | $ 25,000.00 | $ - |
| 3. Process Operation Costs: | | |
| Utility Costs | $ 72,800.00 | $ 37,237.00 |
| Labor Costs | $ 324,000.00 | $ 243,000.00 |
| Routine Maintenance Costs for Processes | $ 24,000.00 | $ - |
| Subtotal | $ 420,800.00 | $ 280,237.00 |
| 4. PPE and Related Health/Safety/Supply Costs | $ - | $ - |
| 5. Waste Management Costs: | | |
| Waste Container Costs | $ - | $ - |
| Treatment/Storage/Disposal Costs | $ - | $ - |
| Inspection/Compliance Costs | $ - | $ - |
| Subtotal | $ - | $ - |
| 6. Recycling Costs | | |
| Material Collection/Separation/Preparation Costs: | | |
| a) Material and Supply Costs | $ - | $ - |
| b) Operations and Maintenance Labor Costs | $ - | $ - |
| Vendor Costs for Recycling | $ - | $ - |
| Subtotal | $ - | $ - |
| 7. Administrative/other Costs (planner) | $ 20,800.00 | $ - |
| Total Annual Cost: | $ 1,266,600.00 | $ 830,237.00 |

* See attached Supporting Data and Calculations.

**Worksheet 2: Itemized Project Funding Requirements***
**(i.e., One Time Implementation Costs)**

| Category | Cost $ |
|---|---|
| **INITIAL CAPITAL INVESTMENT** | |
| 1. Design | $ - |
| 2. Purchase | $ 550,000 |
| 3. Installation | $ - |
| 4. Other Capital Investment (explain) | $ - |
| **Subtotal: Capital Investment= (C)** | $ 550,000 |
| **INSTALLATION OPERATING EXPENSES** | |
| 1. Planning/Procedure Development | $ - |
| 2. Training | $ - |
| 3. Miscellaneous Supplies | $ - |
| 4. Startup/testing 6 mos. | $ - |
| 5. Readiness Reviews/Management Assessment/Administrative Costs 2 wks. | $ - |
| 6. Other Installation Operating Expenses (explain) | $ - |
| **Subtotal: Installation Operating Expense = (E)** | $ - |
| 7. All company adders (G & A/PHMC Fee, MPR, GFS, Overhead, taxes, etc.)(if not contained in above items) | $ - |
| **Total Project Funding Requirements=(C + E)** | $ 550,000 |
| Useful Project Life = (L) 15 Years Time to Implem 0 Months | |
| **Estimated Project Termination/Disassembly Cost (if applicable) = (D)** (Only for Projects where L<5 years; D=0 if L>5 years) | $ - |
| | |
| **TOTAL LIFE-CYCLE COST SAVINGS CALCULATION FOR IPABS-IS** | |
| *(Before - After) x (Useful Life) - (Total Project Funding Requirements + Termination)* | |
| Total Life Cycle Cost Savings Estimate = (B - A) x L - (C+E+D) | $5,995,445 |
| **RETURN ON INVESTMENT CALCULATION** | |

Return on Investment (ROI) % =

$$\frac{\textit{(Before - After) - [(Total Project Funding Requirements + Termination)/Useful Life]}}{\textit{[Total Project Funding Requirements + Project Termination]}} \times 100$$

$$ROI = \frac{(B-A)-[(C+E+D)/L}{(C+E+D)} \times 100 \quad 73 \quad \%$$

| O&M Annual Recurring Costs: | | | Project Funding Requirements: | | | |
|---|---|---|---|---|---|---|
| Annual Costs, Before= | $ 1,266,600 | (B) | Capital Investment= | $ | 550,000 | (C) |
| Annual Costs, After= | $ 830,237 | (A) | Installation Op. Exp= | $ | - | (E) |
| Net Annual Savings= | $ 436,363 | (B-A) | Total Project Funds= | $ | 550,000 | (C+E) |

Note: Before (B) and After (A) are Operating & Maintenance Annual Recurring Costs from Worksheet 1.

# Basis for Estimates

| 1 | Equipment |
|---|---|
| | The cost of the new King, Buck Technology unit was $550,000 in 2001. All three Thermatrix units cost $2, 200,000 in 1996. This figure was adjusted to $2,400,000 for inflation and then divided by 3 for the $800,000 cost per unit. |

| 2 | Purchased Raw Materials and Supplies |
|---|---|
| | There are approximately $25,000 in parts and materials that will not be required for maintenance and repairs for the old Thermatrix unit. |

| 3 | Process Operation Costs: |
|---|---|
| | **Utility Costs**<br>Savings on utilities are based upon a cost of 1,000 gallons of propane used per week, for 52 weeks per year at a cost of $1.40 per gallon which was a recent cost per gallon. This makes for an annual propane budget of $72,800. This is the usage estimate for the oxidizer unit being replaced. Recent estimates prepared for electricity use indicated $29,047 in flat use. This was derived from preheating energy demand of 53.2 kWh times $0.065 per kWh for 8,400 hours of run time per year.This leads to a cost savings of $43,753 annually.<br>**Labor Costs**<br>Engineering and Technical support can be adjusted down when the new unit is operational. Approximately 0.25 FTE of each discipline will be unnecessary. 2 technicians can be reduced to 1.75, and 2 engineers can be reduced to 1.75 FTEs. The dollars saved are based on estimates of $36,000 and $45,000 annual cost respectively for these .25 FTEs.<br>**Routine Maintenance Costs for Processes**<br>A cost of $6,000 is estimated for each maintenance activity. This accounts for 3 craftspeople for 40 hours times $50 per hour for each of 4 activities. . Four of these would be expected per year equalling $24,000 saved annually. |

| 7 | Administrative/other Costs (planner) |
|---|---|
| | A planners time would have been needed to prepare for the maintenance and repair of the old unit. Assuming 4 work packages per year at $5,200 per package, this amounts to $20,800 annually. This estimate is based on 4 packages at 80 hours of work, or 320 hours at an average rate of $65 per hour. |

| Summary |
|---|
| Net annual savings for installation of the new Catalytic Oxidizer amount to $436,363. Over the span of an estimated 15 year life this amounts to $6,545,445. Another significant benefit to adoption of the new technology is the expected improvement in operational uptime. It is hoped that there will be at least a 20% improvement in run time. |

# SCIENCE AND TECHNOLOGY BENEFIT ANALYSIS
# DEPLOYMENT APPROVALS

**Technology Deployed:** KING BUCK CATALYTIC OXIDIZER

**Date Deployed:** 07/18/01

**EM Program(s) Impacted:** Environmental Restoration Program

Approval Signatures

8/21/01

Contractor Program Manager — Date

N/A

Contractor Program Manager — Date

Kathleen E Hain — 8/23/01

DOE-ID Program Manager — Date

N/A

DOE-ID Program Manager — Date